SECTION 7

Performance Verification

Conduct this test to verify ***7200** Series* Ventilator performance.

NOTE:

The procedures in this section do not apply to ventilator accessories. Refer to operator's or service manuals for each accessory. Malfunctioning accessories can affect some ventilator functions and cause false test results.

7.1 When To Run

Run some or all of the performance verification after ventilator service (see,Table 7-1), if ventilator operation is in question, or as required by your institution's protocol.

7.2 Test Equipment and Service Material Required

In addition to the standard set of tools listed in Section 1, the test equipment and material listed in Table 7-2 and Table 7-3 are required for the performance verification.

NOTE:

Before use, verify that all test equipment is calibrated.

Table 7-1: Recommended Performance Verification Intervals

Service Action Performed	Performance Verification Test Requirements
Whenever J11 is disconnected	Test 16 (steps 3-5)
2,500 hour preventive maintenance	All tests
10,000-hour preventive maintenance	All tests
Replacement or removal of proportional solenoid valve assembly	All tests
Replacement or removal of safety valve	All tests
Replacement or removal of REG1/REG2	Tests 2, 3, 9, and 10 (steps 1-11)
Replacement or removal of REG3	Tests 2, 3, 9, and 10 (steps 12-25)
Replacement or removal of REG5	Tests 2, 3, and 14
Replacement or removal of Q1/T1 or Q2/T2 (one flow sensor only)	Tests 2, 3, 12, and 15
Replacement or removal of Q3/T3	Tests 2 and 3
Replacement or removal of more than one flow sensor	All tests
Replacement or removal of interface PCB	Tests 1-3, 11 (steps 1-17), and 12 (steps 16-28)
Replacement or removal of pressure transducer PCB	Tests 2, 3, 11 (steps 18-27), 12, and 14 (steps 21-26)
Replacement or removal of pneumatic chassis assembly	All tests
Replacement or removal of compressor	Tests 1-3, 9 (steps 1-7), and 10 (steps 12-25)
Replacement or removal of power supply assembly	Tests 1-3 and 7
Replacement or removal of any AC components	Tests 1-3 and 7
Replacement or removal of any other components	Tests 1-3

Table 7-2: Test Equipment Required for Performance Verification

Description	Manufacturer/Model
Electrical safety tester	BIO-TEK Model 501 PRO or equivalent
Pneumatic calibration analyzer capable of measuring high pressure (psi), low pressure (cmH_2O digital display), flow rate (lpm), volume (liters BTPS)	*PTS 2000* or Timeter Corporation RT-200 **NOTE:** A *PTS 2000* or an RT-200 is required to test BTPS volume and ATP flow. You can use pressure gauges for other pneumatic testing.
Oxygen analyzer accurate to ±2%	*PTS 2000*, MiniOx 3000 (P/N 4-023698-00), or equivalent
Digital multimeter (DMM) accurate to three decimal places	Local supplier

Table 7-3: Puritan Bennett Service Materials Required for Performance Verification

Description	Quantity	Part No.
Test lung with strap	1	4-000612-00
Test lung without strap	1	4-011355-00
Tee, male barb, 3/16 in. (5 mm)	1	4-000630-00
Tee (patient pressure adapter)	1	4-011521-00
Coupling, female, for barbed cuff fittings	1	4-003443-00
Barb fitting and nut for RT-200 (if used)	1	Local Supplier
Patient tubing circuit with nebulizer (simplified)	1	4-018052-00 or equivalent
Oxygen sensor tee	1	4-020935-00 (used with 7820 Oxygen Monitor or equivalent)
Tube, small-bore, 3/16 in. ID	2	Various parts. See hospital accessories catalog.
No. 2 stopper	1	4-009523-00 or local supplier
No. 2 stopper with 3/16 in. (5 mm) OD barbed connector	1	4-003152-00

7.3 Preliminary Ventilator Cleaning and Inspection

Clean and inspect the ventilator as follows:

Warning

To prevent disease transmission, use personal protective equipment when handling contaminated bacteria filters or other patient accessories. Refer to the *7200 Series Ventilatory System Operator's Manual* for cleaning and sterilization instructions.

1. Clean ventilator exterior (Section 8).
2. Remove any water from humidifier and dry jar, if applicable.
3. Remove top cabinet panel and top cover (Section 19.1.1), back panel and inner panel, as applicable (Section 19.2.1), and swing open left-hand panel (Section 9.1).
4. If ventilator has a compressor pedestal, remove pedestal access panel cover and inner access panel (Section 16.1).
5. Clean interior of ventilator and compressor pedestal (if applicable) by carefully blowing out any dust with deionized gas or by vacuuming with ESD-safe equipment.
6. Inspect air and oxygen filter/water trap assemblies. Clean or replace as required.
7. Remove and inspect electronics compartment cooling fan filter. Clean or replace as required.
8. If ventilator has a compressor, inspect cooling fan filter. Clean or replace as required.
9. Visually inspect ventilator and compressor pedestal exterior and interior for obvious problems, such as missing or broken parts, loose assemblies, or disconnected wires, connectors, or tubing. Perform repairs or adjustments as needed.

7.4 Preliminary Ventilator Setup

Set up the ventilator for the performance verification as follows:

1. Install a complete Puritan Bennett simplified patient tubing circuit (or equivalent) with nebulizer. Make sure all bacteria filters and a humidifier are installed. Make sure humidifier is not filled with water.
2. Connect ventilator to wall or bottled oxygen source.
3. Connect ventilator to wall or bottled air source.
4. Disconnect all communication cables between the 7200 and the 7250.

7.5 Preliminary Test Instrument Setup

Run the performance verification pneumatic tests using either of these test instruments:

- *PTS 2000* performance test system, with or without *BreathLab*™ PTS respiratory products test software, or
- RT-200 pneumatic calibration analyzer.

7.5.1 *PTS 2000* and *BreathLab* PTS Software Setup

For complete information on the *PTS 2000* and *BreathLab* PTS software, please see these manuals:

- *PTS 2000 User's Manual* (P/N 4-076180-00)
- *BreathLab PTS Software User's Manual* (P/N 4-075450-00).

Follow these steps:

1. Turn on the *PTS 2000* and allow 10 minutes to warm up before use.
2. Connect the *PTS 2000* to a computer equipped with RPTS software, if used (Figure 7-1).

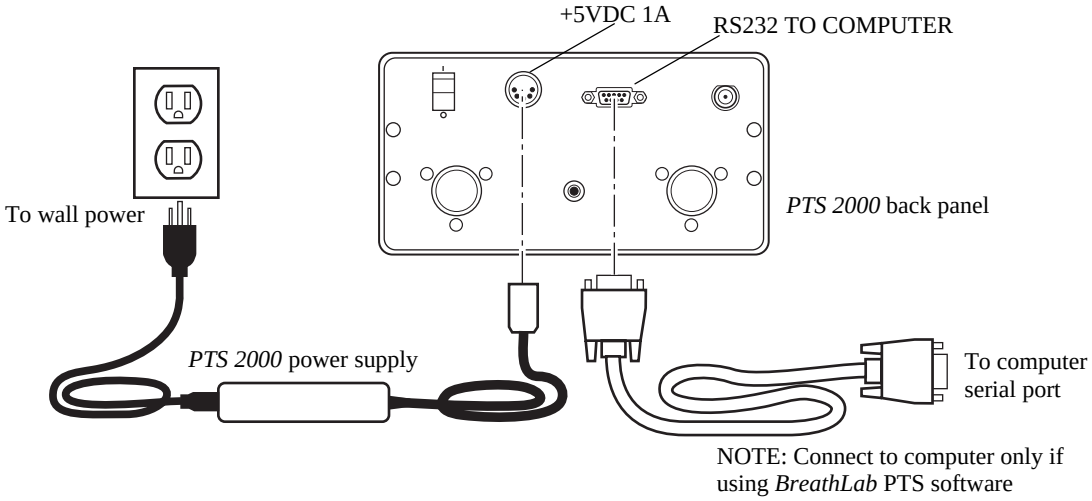


Figure 7-1. Connecting the *PTS 2000* and Computer (if using *BreathLab* PTS software)

3. Attach tubing between the *7200* Ventilator and the *PTS 2000* (Figure 7-2).

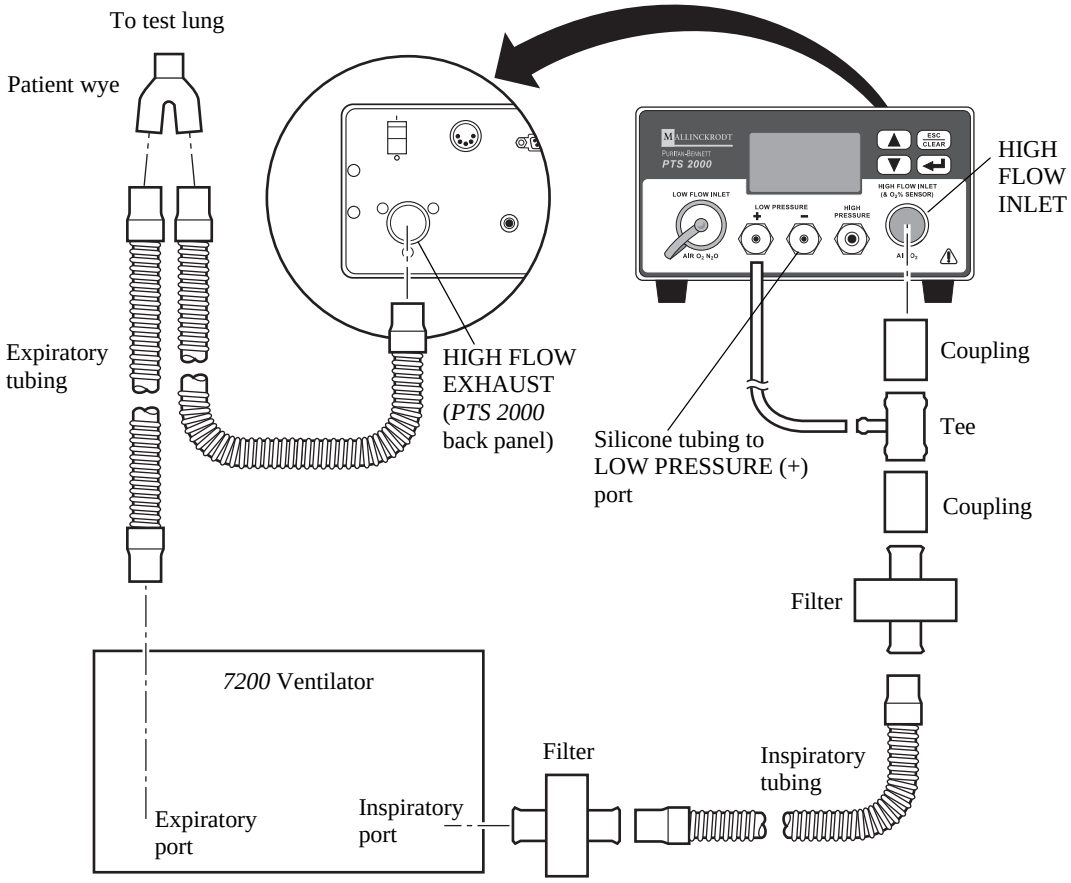


Figure 7-2. Attaching Tubing Between the *7200* Ventilator and *PTS 2000*

4. Once the *PTS 2000* is warmed up, autozero its high and low pressure transducers and calibrate its oxygen sensor as described in the *PTS 2000 User's Manual*.

You can use the *PTS 2000* with or without *BreathLab* software. If using *BreathLab* software:

- Where applicable, the performance verification test steps in this section list the *BreathLab* software screens you can use to test the *7200* Ventilator.
- You can use the *All Parameters* screen for all measurements except volume. For volume measurements, use the *Volume (1 Breath)* screen.
- Be sure to select the correct attributes for each parameter.
- Unless otherwise specified, use the "Current" reading for all measurements.
- Press F7 between each measurement to clear previous data.

7.5.2 RT-200 Setup

To set up the RT-200 for performance verification tests, use a barb fitting and nut on the RT-200 positive high-pressure range port. The barb fitting and nut should remain connected to the RT-200.

NOTE:

- If the RT-200 offers a choice between ATP and BTPS volumes, select the BTPS special function for volume measurements.
- To select ATP or BTPS, select Volume setting, then press 00 and <ENTER>. Use 0 to scroll between STD, ATP, and BTPS. Press <ENTER> to select.

7.6 Performance Verification Procedures

To ensure ventilator performance and logical fault diagnosis, perform these tests in the given order. If a test needs to be repeated, the current control settings are completely defined at the beginning of each individual check.

NOTE:

- If you are running the performance verification tests in order, you need only make the ventilator settings shown in **bold** at the start of each test.
- To determine the possible cause of a malfunction, refer to the numbered item in Section 7.8 (Troubleshooting) that may appear in parenthesis at the end of the step in a test.

Follow these general guidelines when running the performance verification:

- If you note a problem during the performance verification, verify that you followed the procedures correctly before attempting to repair the ventilator.
- Verify that you correctly entered the data on the ventilator keyboard by listening for the keyboard beep and observing the appropriate display.
- Nonstandard tubing connections can cause apnea or other alarm conditions to occur: use <ALARM SILENCE> and <ALARM RESET> as needed.
- Except for <ALARM SILENCE> and <ALARM RESET>, do not change the control settings during these procedures without specific instructions.
- For repair procedures, see Section 8 through Section 19. When repairs are completed, repeat the test. When the test is successful, proceed with the next test, as applicable.

NOTE:

The following procedures do not verify the performance of accessories. Verify the performance of accessories using the manufacturer's instructions for that accessory.

Warning

Follow accepted safety procedures for electrical equipment when making connections, adjustments, or repairs.

7.6.1 Electrical Safety Test (Test 1)

Warning

If the ventilator fails an electrical safety test, correct the problem and retest the unit. Do not proceed to the next electrical safety test until each test is successfully completed.

The electrical safety test verifies that ground resistance, leakage current, and current draw are within safe limits. Perform this test whenever you service the ventilator, according to your institution's requirements.

NOTE:

- Before performing the electrical safety tests, ensure that the compressor (if applicable) and all accessories are connected and running.
- There are no specific ventilator settings for the electrical safety test.

1. Make sure ventilator power is off.
2. **VERIFY** ground resistance is ≤ 0.1 Ω. (See Section 7.8, *Item 1* for troubleshooting information.)
3. If applicable, turn on humidifier. The humidifier temperature should be set to a typical operating value.
4. Turn on ventilator power.
5. If ventilator has a compressor, disconnect wall or bottled air supply from ventilator.
6. Ensure that compressor (if applicable) is running. Failure to do so will produce an inaccurate total leakage current reading.
7. **VERIFY** that forward- and reverse-current leakage to ground is ≤100 µA (100/115 V units) or ≤500 µA (220/240 V units). (See Section 7.8, 2.)
8. **VERIFY** that current draw is in accordance with Table 7-4. (See Section 7.8, *Item 3* for troubleshooting information.)

Table 7-4: Acceptable Current Draw Values

Voltage	Current Draw without Compressor	Current Draw with Compressor
100 V	<4.9 A	<10 A
115 V	<5.3 A	<10 A
220 V	<2.5 A	<4.8 A
240 V	<2.5A	<4.6 A

NOTE:

If ventilator has a compressor, ensure that compressor is connected and running. Failure to do so will produce an inaccurate current draw reading.

9. Turn off humidifier if applicable.
10. **VERIFY** that compressor and electronics compartment cooling fans are operating properly. (See Section 7.8, *Item 4* for troubleshooting information.)
11. Turn off ventilator power.

7.6.2 Power-On Self-Test (POST) (Test 2)

The Power-On Self-Test (POST), in conjunction with the Total Extended Self-Test (TEST), verifies overall ventilator performance. POST is initiated automatically whenever power to the ventilator is turned on. For additional information about POST, refer to Section 5.

1. Turn ventilator power on.
2. **VERIFY** that no POST faults are displayed by either 20-character display or CPU PCB LEDs. (See Section 7.8, *Item 5* for troubleshooting information.)
3. Turn off the ventilator.

7.6.3 Total Extended Self-Test (EST) (Test 3)

Warning

- Do not use or override a ventilator that fails the Total EST without first verifying its operational readiness by an independent means and determining that a patient will not be placed at risk.
- Puritan Bennett urges medical departments to review the implications of using a ventilator that fails test step 541 or 542. Puritan Bennett recommends establishing a medical department protocol that defines the conditions under which ventilator usage is acceptable.
- To avoid patient injury, *do not* initiate EST while a patient is connected to the ventilator. During the EST, the ventilator does not provide normal ventilatory support.

Total Extended Self-Test (EST), in conjunction with POST, verifies overall ventilator performance. For additional information about Total EST, refer to Section 5.

1. Make sure ventilator power is on.
2. Connect wall air.
3. Turn the <PEEP/CPAP> knob to the 25 cmH_2O setting.

NOTE:
There are no specific ventilator setting requirements for EST.

4. Press and hold <EST> button. The ventilator displays [START EST - ENTER] in 20-character display.
5. Press <ENTER>. The ventilator displays [PAT TUBING OFF - ENTER].
6. Press <ENTER> after verifying that a patient is not connected to the ventilator. The ventilator displays [QUICK EST].
7. Press <++>. The ventilator displays [TOTAL EST].
8. Press <0>. Record time, date and status of last EST, values for patient tubing circuit leakage and compliance, and area ratio of exhalation valve, displayed in 7202 Display or 20-character display.
9. Press <I:E RATIO>. Record software part number, software revision level, and installed ventilator options code, displayed in 20-character display.
10. Press <1>. Record four-digit error code and date and time stamp, displayed in 20-character display.
11. Press <RATE bpm>. If available, record 12-digit code, displayed in 20-character display. Refer to Section 5.3.9 to interpret 12-digit code.
12. Repeat steps 9 and 10 using keys <2> through <6> on numeric keypad.
13. Remove test lung from patient wye.
14. Press <ENTER>. Proceed with EST.
15. **VERIFY** the cracking pressure during EST test 573: (See Section 7.8, *Item 6* for troubleshooting information.)

a. Non-EMI units should be between 133-143 cmH_2O inclusive.

b. EMI units should be between 111-121 cmH_2O inclusive.

NOTE:

Determine cracking pressure by watching analog meter or bar graph display while test 573 is running the compliance calculation. The displayed pressure rises to 30 cmH_2O, 60 cmH_2O, then 85 cmH_2O. Then, the pressure level rises slowly in the cmH_2O display of the PATIENT DATA section of the keyboard. The pressure level displayed in the cmH_2O display continues to rise slowly to the cracking pressure, then starts to flicker rapidly as flow increases through ventilator pneumatics. Cracking pressure is the last pressure level displayed before the display starts to flicker.

16. **VERIFY** that the ventilator displays [EST PASS] in the 20-character display. (See Section 7.8, *Item 5* for troubleshooting information.)

    If ventilator is an 8088-based unit or an earlier 80188-based unit, the ventilator displays [REVIEW APNEA PARAMS].

NOTE:

When returning the ventilator to operation after EST, always wait until the ventilator displays [REVIEW APNEA PARAMS]. Do not turn the ventilator power switch off and on. If you do so, the ventilator displays [RUN EST-DO NOT USE] and starts BUV.

17. If ventilator is a later 80188-based unit, the ventilator displays [TEST AC ALARM]. Do the following:

    a. Unplug the ventilator from ac power and **VERIFY** that audible alarm sounds. (See Section 7.8, *Item 32* for troubleshooting information.)

    b. Plug the ventilator back in to ac power.

18. Connect test lung to patient wye.

19. If ventilator is a 7200ae and a *7250* Metabolic Monitor is installed, Volume Calibration must be performed for the ventilator to enter metabolic mode. Refer to the *7250 Metabolic Monitor Service Manual*.

NOTE:

Calibration data is stored in the ventilator's battery-backed RAM. If connector J11 has been disconnected during service, volume calibration must be performed. The Battery-Backed RAM Test (Test 4) verifies that the battery-backed RAM circuits are functioning properly.

7.6.4 Battery-Backed RAM Test (Test 4)

NOTE:

If you are running the performance verification tests in order, you need only make the ventilator settings shown in **bold**.

This test verifies the performance of the battery-backed RAM circuits.

1. Set up the ventilator as follows:

Battery-Backed RAM Test (Test 4) Settings

Control	Setting
Analog meter (basic console only)	**<EXHALED VOLUME liters>**
<PEEP/CPAP> knob	Off
cmH_2O digital display	**<MEAN AIRWAY PRESSURE>**
RATE/I:E digital display	**<RATE bpm>**
liters digital display	**<TIDAL VOLUME>**
<NEBULIZER>	**Off**
Mode	**<CMV>**
Waveform	**Square**
<TIDAL VOLUME>	**0.75 liter**
<RESPIRATORY RATE>	**10 bpm**
<PEAK INSPIRATORY FLOW>	**100 lpm**
<SENSITIVITY>	**20 cmH_2O**
<O_2%>	**21%**
<PLATEAU>	**0 seconds**
<HIGH PRESSURE LIMIT>	**60 cmH_2O**
<LOW INSPIRATION PRESSURE>	**3 cmH_2O**
<LOW PEEP/CPAP PRESSURE>	**0 cmH_2O**
<LOW EXHALED TIDAL VOL>	**0 liters**
<LOW EXHALED MINUTE VOL>	**0 liters**
<HIGH RESPIRATORY RATE>	**0 bpm**
Apnea interval	**60 seconds**
Automatic sigh	Off
Power	On
Patient wye	4-000612-00 test lung
Humidifier (if applicable)	**Off**

2. Turn off ventilator, wait 30 seconds, then turn ventilator back on.
3. **VERIFY** that no POST error codes are displayed by 20-character display or CPU PCB LEDs. (See Section 7.8, *Item 7* for troubleshooting information.)
4. **VERIFY** that there are no changes to the settings in step 1 due to the power interruption. (See Section 7.8, *Item 1*, *Item 6*, *Item 8*, and *Item 32* for troubleshooting information.)

7.6.5 Lamp Test (Test 5)

The lamp test verifies the performance of the lamps, indicators, displays, analog meter (if applicable), and audio alarm.

1. Set up the ventilator as follows (no change from end of Test 4):

Lamp Test (Test 5) Settings

Control	Setting
Analog meter (basic console only)	<EXHALED VOLUME liters>
<PEEP/CPAP> knob	Off
cmH2O digital display	<MEAN AIRWAY PRESSURE>
RATE/I:E digital display	<RATE bpm>
liters digital display	<TIDAL VOLUME>
<NEBULIZER>	Off
Mode	<CMV>
Waveform	Square
<TIDAL VOLUME>	0.75 liter
<RESPIRATORY RATE>	10 bpm
<PEAK INSPIRATORY FLOW>	100 lpm
<SENSITIVITY>	20 cmH2O
<O2%>	21%
<PLATEAU>	0 seconds
<HIGH PRESSURE LIMIT>	60 cmH2O
<LOW INSPIRATION PRESSURE>	3 cmH2O
<LOW PEEP/CPAP PRESSURE>	0 cmH2O
<LOW EXHALED TIDAL VOL>	0 liters
<LOW EXHALED MINUTE VOL>	0 liters
<HIGH RESPIRATORY RATE>	0 bpm
Apnea interval	60 seconds
Automatic sigh	Off
Power	On
Patient wye	4-000612-00 test lung
Humidifier (if applicable)	Off

2. Press <LAMP TEST> and then <ENTER>.

NOTE:

If you have an 80188-based or earlier 8088-based unit, the ventilator displays the software revision and option code in the 20-character display.

3. **VERIFY** that all lamps, indicators, displays, the audio alarm, and the analog meter or bar graph LEDs (whichever is applicable) are activated in the sequence shown in Figure 7-3, Figure 7-4, or Figure 7-5. (See Section 7.8, *Item 9* for troubleshooting information.)

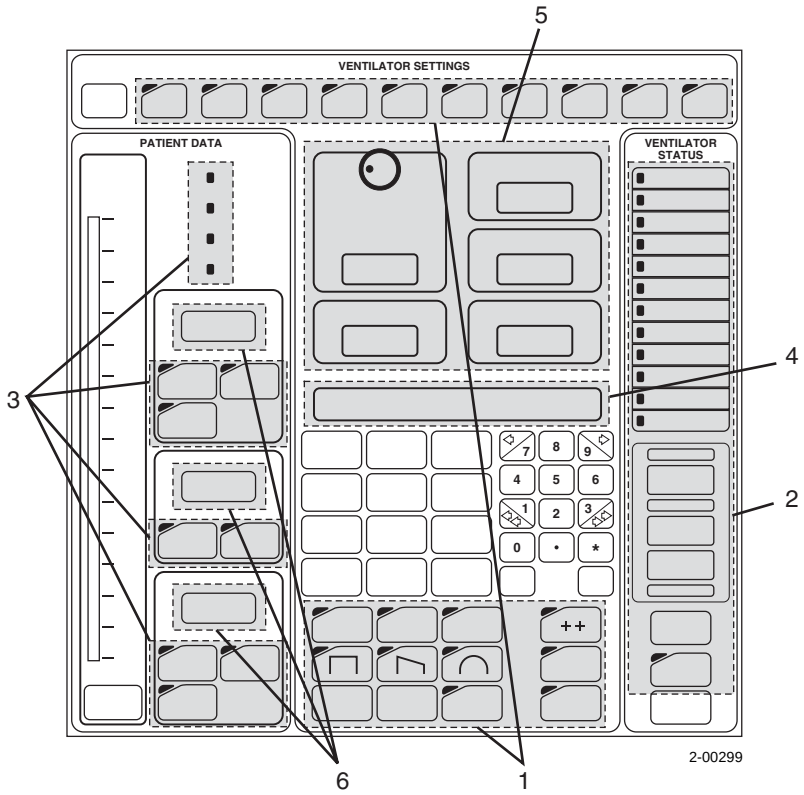


Figure 7-3. Enhanced-Plus Keyboard Lamp Test Sequence

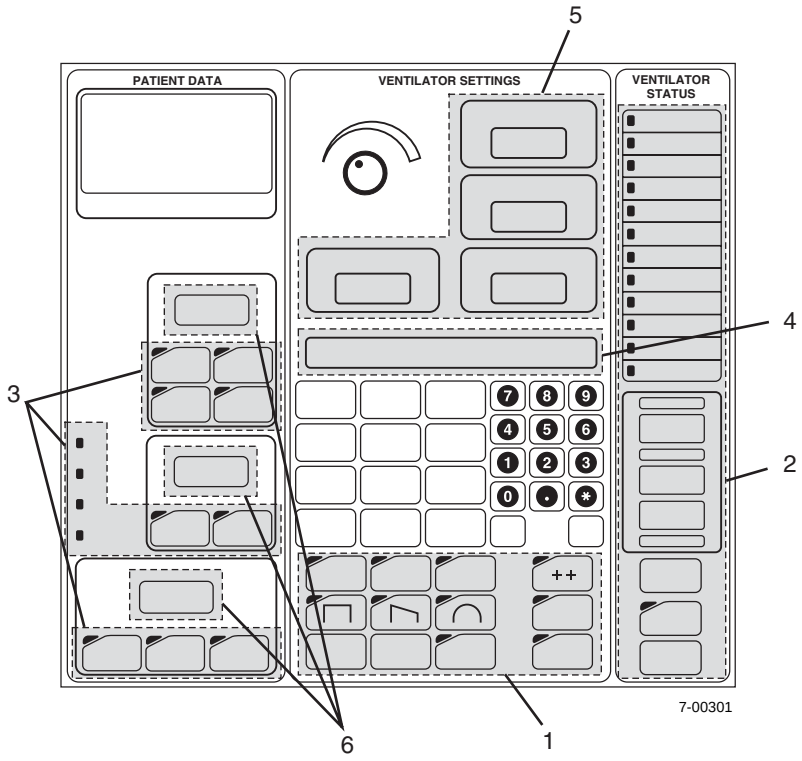


Figure 7-4. Enhanced Keyboard Lamp Test Sequence

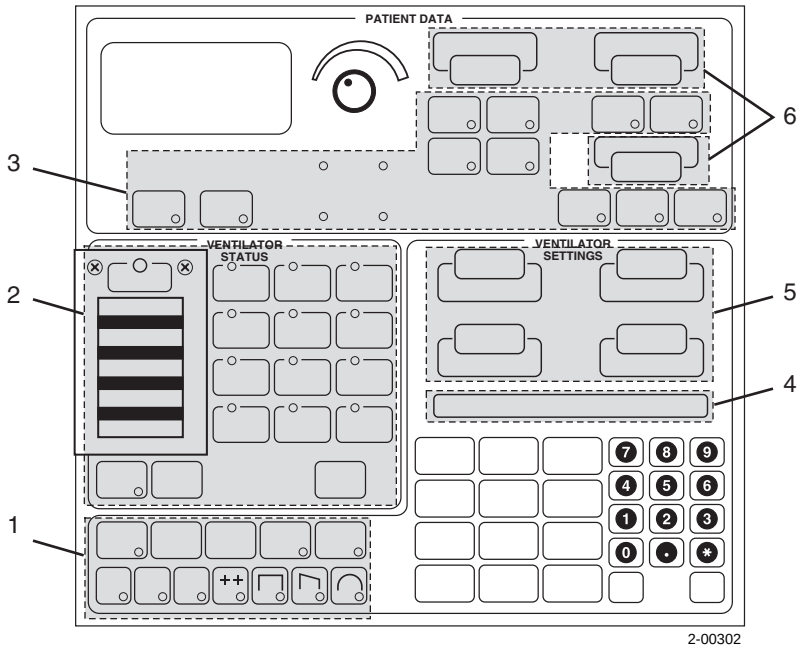


Figure 7-5. Basic Keyboard Lamp Test Sequence

7.6.6 Analog Output Connector Test (Test 6)

The analog output connector test verifies the performance of the pressure level and flow rate level portions of the analog output signal connector, located on the utility panel.

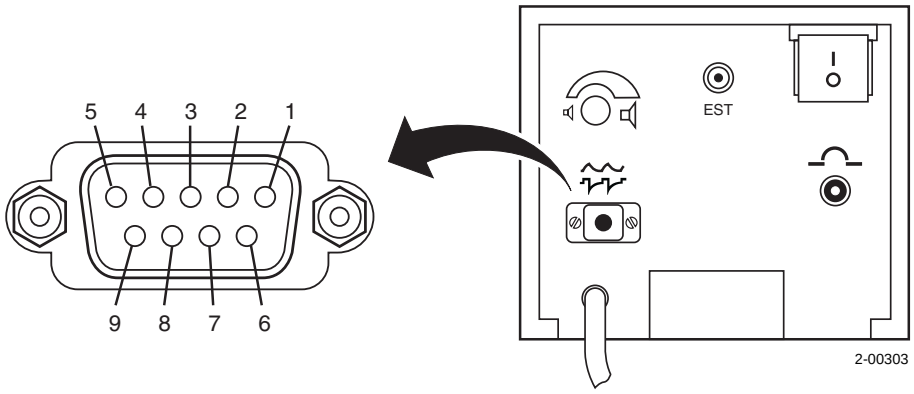
1. Set up the ventilator as follows (no change from end of Test 5):

Analog Output Connector Test (Test 6) Settings

Control	Setting
Analog meter (basic console only)	<EXHALED VOLUME liters>
<PEEP/CPAP> knob	Off
cmH_2O digital display	<MEAN AIRWAY PRESSURE>
RATE/I:E digital display	<RATE bpm>
liters digital display	<TIDAL VOLUME>
<NEBULIZER>	Off
Mode	<CMV>
Waveform	Square
<TIDAL VOLUME>	0.75 liter
<RESPIRATORY RATE>	10 bpm
<PEAK INSPIRATORY FLOW>	100 lpm
<SENSITIVITY>	20 cmH_2O
<O_2%>	21%
<PLATEAU>	0 seconds
<HIGH PRESSURE LIMIT>	60 cmH_2O
<LOW INSPIRATION PRESSURE>	3 cmH_2O
<LOW PEEP/CPAP PRESSURE>	0 cmH_2O
<LOW EXHALED TIDAL VOL>	0 liters
<LOW EXHALED MINUTE VOL>	0 liters
<HIGH RESPIRATORY RATE>	0 bpm
Apnea interval	60 seconds
Automatic sigh	Off
Power	On
Patient wye	4-000612-00 test lung
Humidifier (if applicable)	Off

2. Set DMM to 10 V dc scale.
3. Prepare to measure analog output connector signals by inserting miniature DMM leads into connector (pin 2-positive lead, pin 3-negative lead) or by mating a 9-pin, D-type male test connector to analog output connector so voltages can be measured more easily. See Figure 7-6 for connector pinout.
4. Turn on ventilator power.
5. After POST is completed, press <LAMP TEST> and <ENTER>.
6. **VERIFY** that DMM displays five different voltage levels: 0, +2.5, +5.0, +7.5, and +10.0 V (all within a tolerance of $\pm$ 0.2 V). (See Section 7.8, *Item 10* for troubleshooting information.)

7. Turn off ventilator power.
8. Insert DMM probes into analog output connector (pin 6-positive lead, pin 7-negative lead).
9. Turn on ventilator power.
10. After POST is completed, press <LAMP TEST> and <ENTER>.
11. **VERIFY** that DMM displays the same five voltage levels as in step 6. (See Section 7.8, *Item 10* for troubleshooting information.)
12. Turn off ventilator power.
13. Disconnect DMM and test connector from ventilator.



Pin Number	Description of Signal
Connector Shell	Chassis ground: Do not use to connect protective shield to chassis ground. The protective shield must be connected to chassis ground on pin 1
1	Chassis ground: To be used for protective shield only. The protective shield must also be connected to chassis ground on the peripheral equipment.
2	Pressure signal: 0 to +10 V, corresponding to -20 cmH_2O to +120 cmH_2O. 0 cmH_2O equals approximately 1.4 V. Required impedance matching is 1 kΩ minimum.
3	Pressure signal return
4	– –
5	– –
6	Flow signal: 0 to +10 V, corresponding to -180 lpm to +180 lpm. 0 lpm equals +5.0 V. Required impedance matching is 1 kΩ minimum.
7	Flow signal return
8	Nurse's call relay: Normally open; closed when activated. Allowable current is 250 mA at +30 V (maximum).
9	Nurse's call relay return

Figure 7-6. Analog Output Connector Pinout

7.6.7 Power Supply Test (Test 7)

This test verifies the performance of the power supply.

1. Set up the ventilator as follows (**bold** indicates settings change from end of Test 6):

Power Supply Test (Test 6) Settings

Control	Setting
Analog meter (basic console only)	<EXHALED VOLUME liters>
<PEEP/CPAP> knob	Off
cmH_2O digital display	<MEAN AIRWAY PRESSURE>
RATE/I:E digital display	<RATE bpm>
liters digital display	<TIDAL VOLUME>
<NEBULIZER>	**On**
Mode	<CMV>
Waveform	Square
<TIDAL VOLUME>	0.75 liter
<RESPIRATORY RATE>	10 bpm
<PEAK INSPIRATORY FLOW>	100 lpm
<SENSITIVITY>	20 cmH2O
<O2%>	21%
<PLATEAU>	0 seconds
<HIGH PRESSURE LIMIT>	60 cmH2O
<LOW INSPIRATION PRESSURE>	3 cmH2O
<LOW PEEP/CPAP PRESSURE>	0 cmH2O
<LOW EXHALED TIDAL VOL>	0 liters
<LOW EXHALED MINUTE VOL>	0 liters
<HIGH RESPIRATORY RATE>	0 bpm
Apnea interval	60 seconds
Automatic sigh	Off
Power	On
Patient wye	4-000612-00 test lung
Humidifier (if applicable)	Off

NOTE:
Always use insulated test leads to avoid shorting pins.

2. Connect DMM leads to motherboard connector J14 as indicated in Figure 7-7. Turn on ventilator power. **VERIFY** the voltages while running the lamp test (to load the +5 V and +12 V supplies). (See Section 7.8, *Item 11* for troubleshooting information.)
3. Disconnect DMM leads.

Voltage to be Measured	Positive Lead	Negative Lead	Acceptable Range
+5 V	Pin 9	Pin 11	+4.95 to +5.05 V
+12 V	Pin 13	Pin 11	+11.88 to +12.12 V
+15 V	Pin 7	Pin 5	+14.85 to +15.15 V
-15 V	Pin 4	Pin 5	-15.15 to -14.85 V

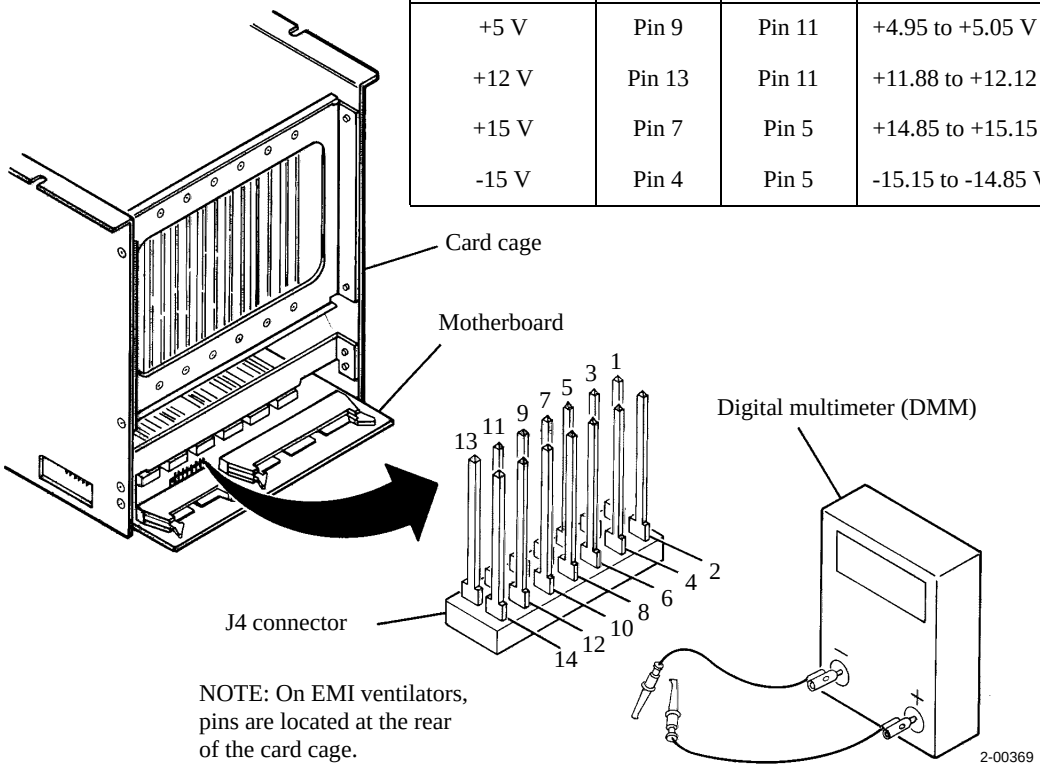


Figure 7-7. Testing Power Supply Output Voltages (non-EMI card cage shown)

7.6.8 Keyboard Test (Test 8)

This test verifies the performance of the keyboard.

1. Set up the ventilator as follows (**bold** indicates settings change from end of Test 7):

Keyboard Test (Test 8) Settings

Control	Setting
Analog meter (basic console only)	**<EXHALED VOLUME liters>**
<PEEP/CPAP> knob	Off
cmH2O digital display	**<MEAN AIRWAY PRESSURE>**
RATE/I:E digital display	**<RATE bpm>**
liters digital display	**<TIDAL VOLUME>**
<NEBULIZER>	**Off**
Mode	<CMV>
Waveform	Square
<TIDAL VOLUME>	0.75 liter
<RESPIRATORY RATE>	10 bpm
<PEAK INSPIRATORY FLOW>	100 lpm
<SENSITIVITY>	20 cmH2O
<O2%>	21%
<PLATEAU>	0 seconds
<HIGH PRESSURE LIMIT>	60 cmH2O
<LOW INSPIRATION PRESSURE>	3 cmH2O
<LOW PEEP/CPAP PRESSURE>	0 cmH2O
<LOW EXHALED TIDAL VOL>	0 liters
<LOW EXHALED MINUTE VOL>	0 liters
<HIGH RESPIRATORY RATE>	0 bpm
Apnea interval	60 seconds
Automatic sigh	Off
Power	On
Patient wye	4-000612-00 test lung
Humidifier (if applicable)	Off

2. One at a time, press each key on keyboard. Do not press <ENTER>. **VERIFY** that you hear a beep for each key press. To silence a continuous alarm during this step, press <ALARM SILENCE>. (See Section 7.8, *Item 12* for troubleshooting information.)

7.6.9 Gas Supply System Test (Test 9)

This test verifies the performance of the oxygen and air supply system.

NOTE:
Do not turn on RT-200 Peak Hold during this test.

1. Set up the ventilator as follows (**bold** indicates settings change from end of Test 8):

Gas Supply System Test (Test 9) Settings

Control	Setting
Analog meter (basic console only)	<EXHALED VOLUME liters>
<PEEP/CPAP> knob	Off
cmH_2O digital display	<MEAN AIRWAY PRESSURE>
RATE/I:E digital display	<RATE bpm>
liters digital display	<TIDAL VOLUME>
<NEBULIZER>	Off
Mode	<CMV>
Waveform	Square
<TIDAL VOLUME>	**2.5 liters**
<RESPIRATORY RATE>	**5 bpm**
<PEAK INSPIRATORY FLOW>	**40 lpm**
<SENSITIVITY>	20 cmH_2O
<O_2%>	21%
<PLATEAU>	0 seconds
<HIGH PRESSURE LIMIT>	60 cmH_2O
<LOW INSPIRATION PRESSURE>	3 cmH_2O
<LOW PEEP/CPAP PRESSURE>	0 cmH_2O
<LOW EXHALED TIDAL VOL>	0 liters
<LOW EXHALED MINUTE VOL>	0 liters
<HIGH RESPIRATORY RATE>	0 bpm
Apnea interval	60 seconds
Automatic sigh	Off
Power	On
Patient wye	Open
Humidifier (if applicable)	Off

2. Connect wall air.
3. ***PTS 2000* and *BreathLab*:** Select the *High Pressure (0-100 psig)* parameter or *All Parameters* screen for display.
   RT-200: Select setting for 20 psi. Zero RT-200.
4. Disconnect nebulizer tube from nebulizer, and connect it to the positive High Pressure port on the test instrument (Figure 7-8).

5. Press <NEBULIZER>, then <ENTER> to turn nebulizer on.
6. **VERIFY** a pressure reading between 9.9 and 11.0 psig during inspiration. (See Section 7.8, *Item 13* for troubleshooting information.)
7. If ventilator has a compressor, disconnect wall air, and **VERIFY** a pressure reading between 9.9 and 11.0 psig during inspiration. (See Section 7.8, *Item 14* for troubleshooting information.)
8. Set <O_2%> to 100.
9. **VERIFY** a pressure reading between 9.9 and 11.0 psig during inspiration. (See Section 7.8, *Item 15* for troubleshooting information.)
10. Press <NEBULIZER>, then <ENTER> to turn nebulizer off.
11. Reconnect nebulizer tube to nebulizer.

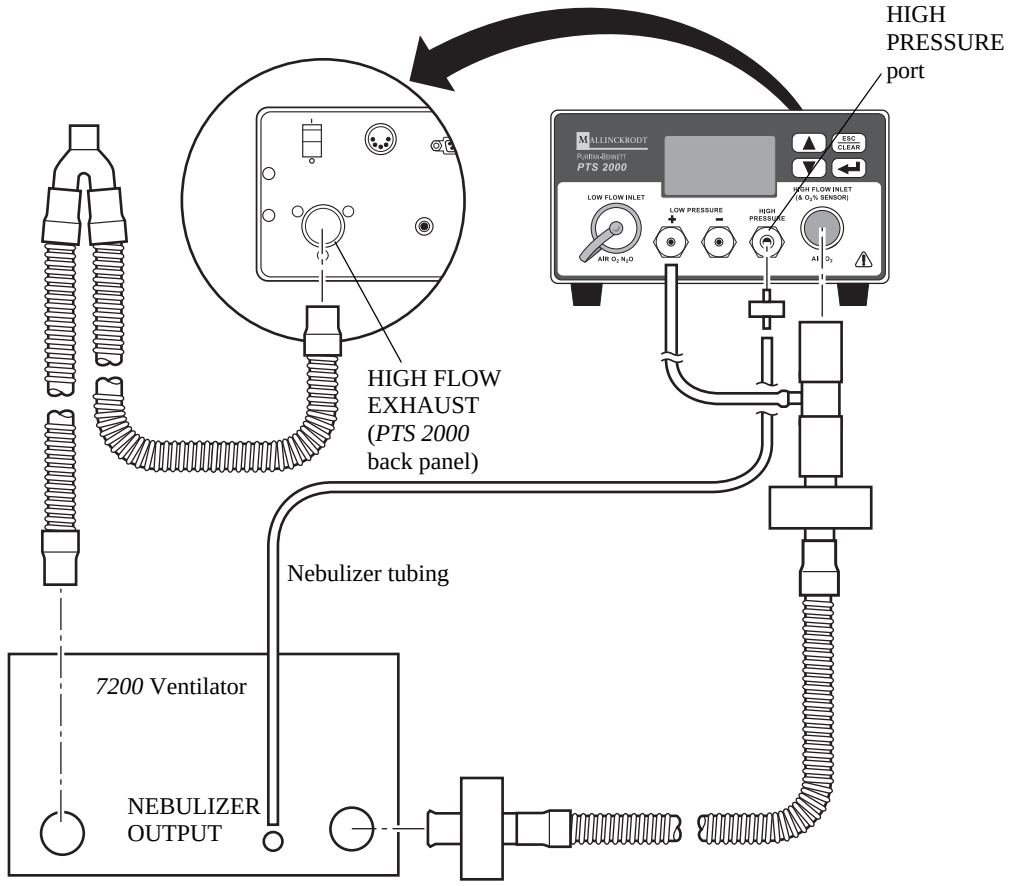


Figure 7-8. Attaching Nebulizer Tubing to *PTS 2000* (Tests 9 and 10)

7.6.10 Peak Inspiratory Flow Test (Test 10)

This test verifies correct peak inspiratory flow.

NOTE:

- The Low Inspiration Pressure (LIP) and apnea alarms are activated during this test. The LIP alarm prevents the ventilator from going into apnea ventilation. To prevent apnea ventilation from starting, set <LOW INSPIRATION PRESSURE> to 20 cmH_2O *before* putting ventilator into CPAP mode.
- Set the test instrument to BTPS for this test.

1. Set up the ventilator as follows (**bold** indicates settings change from end of Test 9):

Peak Inspiratory Flow Test (Test 10) Settings

Control	Setting
Analog meter (basic console only)	<EXHALED VOLUME liters>
<PEEP/CPAP> knob	Off
cmH_2O digital display	<MEAN AIRWAY PRESSURE>
RATE/I:E digital display	<RATE bpm>
liters digital display	<TIDAL VOLUME>
<NEBULIZER>	Off
Mode	**<CMV>**
Waveform	Square
<TIDAL VOLUME>	2.5 liters
<RESPIRATORY RATE>	5 bpm
<PEAK INSPIRATORY FLOW>	40 lpm
<SENSITIVITY>	**0.5 cmH_2O**
<O_2%>	100%
<PLATEAU>	0 seconds
<HIGH PRESSURE LIMIT>	60 cmH_2O
<LOW INSPIRATION PRESSURE>	**20 cmH2O**
<LOW PEEP/CPAP PRESSURE>	0 cmH_2O
<LOW EXHALED TIDAL VOL>	0 liters
<LOW EXHALED MINUTE VOL>	0 liters
<HIGH RESPIRATORY RATE>	0 bpm
Apnea interval	60 seconds
Automatic sigh	Off
Power	On
Patient wye	Open
Humidifier (if applicable)	Off

2. ***PTS 2000* and *BreathLab*:** Select the *High Pressure (0-100 psig)* and *High Flow (0-300 slpm)* parameters or the *All Parameters* screen for display. Set the High Flow attributes to *LPM* and *Oxygen*. Set the High Pressure attribute to *psig*.
   RT-200: Select setting for 180 lpm Oxygen. Zero RT-200. Set Peak/Continuous function off.
3. Connect patient wye to test instrument High Flow port using connector (P/N 4-003443-00).
4. Raise <PEEP/CPAP> knob to maximum.
5. **VERIFY** that test instrument reads greater than 162 lpm. (See Section 7.8, *Item 16* for troubleshooting information.)
6. Lower <PEEP/CPAP> knob to 0 cmH_2O.
7. Set <O_2%> to 21.
8. ***PTS 2000* and *BreathLab*:** Set the High Flow attribute to *Air*.
   RT-200: Select setting for 180 lpm Air. Zero RT-200 during exhalation.
9. Raise <PEEP/CPAP> knob to maximum.
10. **VERIFY** that test instrument reads greater than 162 lpm. If wall air is not available, this step cannot be completed. (See Section 7.8, *Item 17* for troubleshooting information.)
11. Lower <PEEP/CPAP> knob to 0 cmH_2O.
12. If ventilator has a compressor, perform the remaining steps of this test. If not, go to Section 7.6.11; Test 11.
13. Disconnect air supply from ventilator.
14. Raise <PEEP/CPAP> knob to maximum.
15. **VERIFY** that test instrument reads greater than 110 lpm. (See Section 7.8, *Item 18* for troubleshooting information.)
16. Lower <PEEP/CPAP> knob to 0 cmH_2O.
17. **RT-200:** Select setting for 20 psi. Zero RT-200.
18. Disconnect nebulizer tube from nebulizer, and connect it to the High Pressure port on the test instrument.
19. Press <NEBULIZER>, then <ENTER> to turn nebulizer on.
20. Raise <PEEP/CPAP> knob to maximum.
21. **VERIFY** that test instrument reads greater than 7.4 psig during inspiration. (See Section 7.8, *Item 19* for troubleshooting information.)
22. Lower <PEEP/CPAP> knob to 0 cmH_2O.
23. Press <NEBULIZER>, then <ENTER> to turn nebulizer off.
24. Reconnect nebulizer tube to nebulizer.
25. Reconnect air supply to ventilator.

7.6.11 High-Pressure Limit Alarm, Alarm Volume Control, and Nurse's Call Relay Test (Test 11)

This test verifies the performance of the high-pressure limit alarm, alarm volume control, and nurse's call relay.

1. Set up the ventilator as follows (**bold** indicates settings change from end of Test 10):

High-Pressure LImit Alarm, Alarm Volume Control, and Nurse's Call Relay Test (Test 11) Settings

Control	Setting
Analog meter (basic console only)	**<AIRWAY PRESSURE cmH2O>**
<PEEP/CPAP> knob	Off
cmH_2O digital display	**<PEAK AIRWAY PRESSURE>**
RATE/I:E digital display	<RATE bpm>
liters digital display	<TIDAL VOLUME>
<NEBULIZER>	Off
Mode	**<CMV>**
Waveform	Square
<TIDAL VOLUME>	**1.5 liters**
<RESPIRATORY RATE>	**1.5 bpm**
<PEAK INSPIRATORY FLOW>	**15 lpm**
<SENSITIVITY>	**20 cmH2O**
<O2%>	**100%**
<PLATEAU>	0 seconds
<HIGH PRESSURE LIMIT>	**60 cmH2O**
<LOW INSPIRATION PRESSURE>	20 cmH_2O
<LOW PEEP/CPAP PRESSURE>	0 cmH_2O
<LOW EXHALED TIDAL VOL>	0 liters
<LOW EXHALED MINUTE VOL>	0 liters
<HIGH RESPIRATORY RATE>	0 bpm
Apnea interval	60 seconds
Automatic sigh	Off
Power	Off
Patient wye	Open
Humidifier (if applicable)	Off

2. Set DMM to read resistance.
3. Insert miniature DMM probes to test NURSE'S CALL signal via analog output connector (pin 8 and pin 9, polarity unimportant). See Figure 7-6 for connector pinout.
4. Turn on ventilator.
5. Press <ALARM RESET>.
6. **VERIFY** that DMM reads infinite resistance (open circuit). (See Section 7.8, *Item 20* for troubleshooting information.)

7. Block patient wye with no. 2 stopper.
8. Press <ALARM RESET>.
9. Press <MANUAL INSPIRATION>.
10. **VERIFY** that ventilator analog and digital pressure displays read 56 to 63 cmH_2O, and that high pressure limit alarm activates. (See Section 7.8, *Item 21* for troubleshooting information.)
11. **VERIFY** that DMM reads zero resistance (short circuit). (See Section 7.8, *Item 22* for troubleshooting information.)
12. Slowly rotate alarm volume control on utility panel from fully counterclockwise position to fully clockwise position.
13. **VERIFY** that alarm volume steadily increases. (See Section 7.8, *Item 23* for troubleshooting information.)
14. Set <HIGH PRESSURE LIMIT> to 120 cmH_2O (all units except German) or 100 cmH_2O (German units).
15. Press <ALARM RESET>.
16. **VERIFY** that when alarm is off, DMM reads infinite resistance (open circuit). (See Section 7.8, *Item 24* for troubleshooting information.)
17. Disconnect DMM.
18. Block the wye with a stopper with a pressure tap (p/n 4-003152-00 or equivalent). Connect a small bore tube between the pressure trap and the test instrument's Low Pressure positive port.
19. Press the <TIDAL VOLUME> key and set the value to 2.5 liters.
20. Press the <HIGH PRESSURE LIMIT> key and set the value to 95 cmH_2O.
21. ***PTS 2000* and *BreathLab*:** Select the *Low Pressure (+/- 150 cm H2O)* parameter or *All Parameters* screen for display. Set the Low Pressure attributes to *cm H2O* and *Continuous*.
    RT-200: Select setting for 20 cmH_2O. Set Peak/Continuous function to off.
22. Press the <MANUAL INSPIRATION> key.
23. **VERIFY** that the pressure difference between the test instrument and the ventilator's [PEAK AIRWAY PRESSURE] is ≤7 cmH_2O. (See Section 7.8, *Item 34* for troubleshooting information.)
24. **RT-200:** Select setting for 250 cmH_2O.
25. Press the <HIGH PRESSURE LIMIT> key and set the value to 60 cmH_2O.
26. Press the <MANUAL INSPIRATION> key on the ventilator.
27. **VERIFY** that the pressure difference between the test instrument and the ventilator's [PEAK AIRWAY PRESSURE] is ≤4.5 cmH_2O. (See Section 7.8, *Item 34* for troubleshooting information.)

7.6.12 Gas Volume Accuracy Test (Test 12)

The gas volume accuracy test verifies the accuracy of the volume of gas delivered to the patient.

1. Set up the ventilator as follows (**bold** indicates settings change from end of Test 11):

Gas Volume Accuracy Test (Test 12) Settings

Control	Setting
Analog meter (basic console only)	<AIRWAY PRESSURE cmH_2O>
<PEEP/CPAP> knob	Off
cmH_2O digital display	<PEAK AIRWAY PRESSURE>
RATE/I:E digital display	<RATE bpm>
liters digital display	<TIDAL VOLUME>
<NEBULIZER>	Off
Mode	<CMV>
Waveform	Square
<TIDAL VOLUME>	**0.25 liter**
<RESPIRATORY RATE>	1.5 bpm
<PEAK INSPIRATORY FLOW>	**20 lpm**
<SENSITIVITY>	20 cmH_2O
<O_2%>	**100%**
<PLATEAU>	0 seconds
<HIGH PRESSURE LIMIT>	**120 cmH_2O (except German ventilators)** **100 cmH_2O (German ventilators only)**
<LOW INSPIRATION PRESSURE>	20 cmH_2O
<LOW PEEP/CPAP PRESSURE>	0 cmH_2O
<LOW EXHALED TIDAL VOL>	0 liters
<LOW EXHALED MINUTE VOL>	0 liters
<HIGH RESPIRATORY RATE>	0 bpm
Apnea interval	60 seconds
Automatic sigh	Off
Power	On
Patient wye	Open
Humidifier (if applicable)	Off

2. ***PTS 2000* and *BreathLab*:** Select the *Volume (1 Breath)* screen for display. Set the attributes to *L*, *BTPS*, *Oxygen*, and *Inspiration Threshold* and *Expiration Threshold* of 10. Select *MULTI* and *Start* before making a measurement.
   RT-200: Select setting for Volume Oxygen and the BTPS function. Zero RT-200.
3. Connect patient wye to test instrument High Flow port with connector (P/N 4-003443-00).
4. Press <MANUAL INSPIRATION>, then pause. Repeat five times.
5. **VERIFY** that test instrument reads between 0.22 and 0.30 liter. (See Section 7.8, *Item 25* for troubleshooting information.)

6. Set <TIDAL VOLUME> to 1.5 liters.
7. Press <MANUAL INSPIRATION>, then pause. Repeat three times.
8. **VERIFY** that test instrument reads between 1.4 and 1.75 liters. (See Section 7.8, *Item 25* for troubleshooting information.)
9. Set <O_2%> to 21.
10. ***PTS 2000* and *BreathLab*:** Change attribute to *Air*.
    RT-200: Select setting for Volume Air and the BTPS function. Zero RT-200 during exhalation.
11. Press <MANUAL INSPIRATION>, then pause. Repeat five times.
12. **VERIFY** that test instrument reads between 1.44 and 1.82 liters. (See Section 7.8, *Item 25* for troubleshooting information.)
13. Set <TIDAL VOLUME> to 0.25 liter.
14. Press <MANUAL INSPIRATION>, then pause. Repeat three times.
15. **VERIFY** that test instrument reads between 0.23 and 0.30 liter. (See Section 7.8, *Item 25* for troubleshooting information.)

7.6.13 Sensitivity Accuracy Test (Test 13)

The sensitivity accuracy test verifies the accuracy of the sensitivity measurement.

1. Set up the ventilator as follows (**bold** indicates settings change from end of Test 12):

Sensitivity Accuracy Test (Test 13) Settings

Control	Setting
Analog meter (basic console only)	<AIRWAY PRESSURE cmH_2O>
<PEEP/CPAP> knob	Off
cmH_2O digital display	<PEAK AIRWAY PRESSURE>
RATE/I:E digital display	<RATE bpm>
liters digital display	<TIDAL VOLUME>
<NEBULIZER>	Off
Mode	<CMV>
Waveform	Square
<TIDAL VOLUME>	**1 liter**
<RESPIRATORY RATE>	1.5 bpm
<PEAK INSPIRATORY FLOW>	**100 lpm**
<SENSITIVITY>	**10 cmH_2O**
<O_2%>	21%
<PLATEAU>	0 seconds
<HIGH PRESSURE LIMIT>	120 cmH_2O (except German ventilators) 100 cmH_2O (German ventilators only)
<LOW INSPIRATION PRESSURE>	**3 cmH_2O**
<LOW PEEP/CPAP PRESSURE>	0 cmH_2O
<LOW EXHALED TIDAL VOL>	0 liters
<LOW EXHALED MINUTE VOL>	0 liters
<HIGH RESPIRATORY RATE>	0 bpm
Apnea interval	60 seconds
Automatic sigh	Off
Power	On
Patient wye	4-000612-00 test lung
Humidifier (if applicable)	Off

2. Disconnect tubes and connectors from test instrument.
3. Squeeze and very slowly release test lung.
4. **VERIFY** that an assist breath is triggered at -9 to -11 cmH_2O as displayed on analog meter or on bar graph display. (See Section 7.8, *Item 26* for troubleshooting information.)
5. Set <SENSITIVITY> to 5 cmH_2O.
6. Squeeze and very slowly release test lung.
7. **VERIFY** that an assist breath is triggered at -4 to -6 cmH_2O as displayed on analog meter or bar graph display. (See Section 7.8, *Item 26* for troubleshooting information.)

8. Set <SENSITIVITY> to 0.5 cmH_2O.
9. Squeeze and very slowly release test lung.
10. **VERIFY** that an assist breath is triggered at approximately -0.5 cmH_2O as displayed on analog meter or bar graph display. (See Section 7.8, *Item 26* for troubleshooting information.)

7.6.14 PEEP System Test (Test 14)

This test verifies the performance of the PEEP system.

1. Set up the ventilator as follows (**bold** indicates settings change from end of Test 13):

PEEP System Test (Test 14) Settings

Control	Setting
Analog meter (basic console only)	<AIRWAY PRESSURE cmH_2O>
<PEEP/CPAP> knob	Off
cmH_2O digital display	**<PEEP/CPAP>**
RATE/I:E digital display	<RATE bpm>
liters digital display	<TIDAL VOLUME>
<NEBULIZER>	Off
Mode	<CMV>
Waveform	Square
<TIDAL VOLUME>	**0.5 liter**
<RESPIRATORY RATE>	**1 bpm**
<PEAK INSPIRATORY FLOW>	**20 lpm**
<SENSITIVITY>	**20 cmH_2O**
<O_2%>	21%
<PLATEAU>	0 seconds
<HIGH PRESSURE LIMIT>	120 cmH_2O (except German ventilators) 100 cmH_2O (German ventilators only)
<LOW INSPIRATION PRESSURE>	3 cmH_2O
<LOW PEEP/CPAP PRESSURE>	0 cmH_2O
<LOW EXHALED TIDAL VOL>	0 liters
<LOW EXHALED MINUTE VOL>	0 liters
<HIGH RESPIRATORY RATE>	0 bpm
Apnea interval	60 seconds
Automatic sigh	Off
Power	On
Patient wye	4-011355-00 test lung and 4-003152-00 No. 2 stopper with pressure tap or equivalent
Humidifier (if applicable)	Off

2. ***PTS 2000* and *BreathLab*:** Select the *Low Pressure (+/- 150 cm H2O)* parameter or *All Parameters* screen for display. Set the Low Pressure attribute to *cm H2O*.
   RT-200: Select setting for 250 cmH_2O. Zero RT-200.

NOTE:

If the ventilator has a bottom-loading exhalation compartment, remove the front cover to access the exhalation valve pilot tube

3. Tee into patient circuit at wye using coupling (P/N 4-003443-00), tee (P/N 4-011521-00), and one small-bore tube. Connect one end to the test instrument's positive Low Pressure port (Figure 7-9).

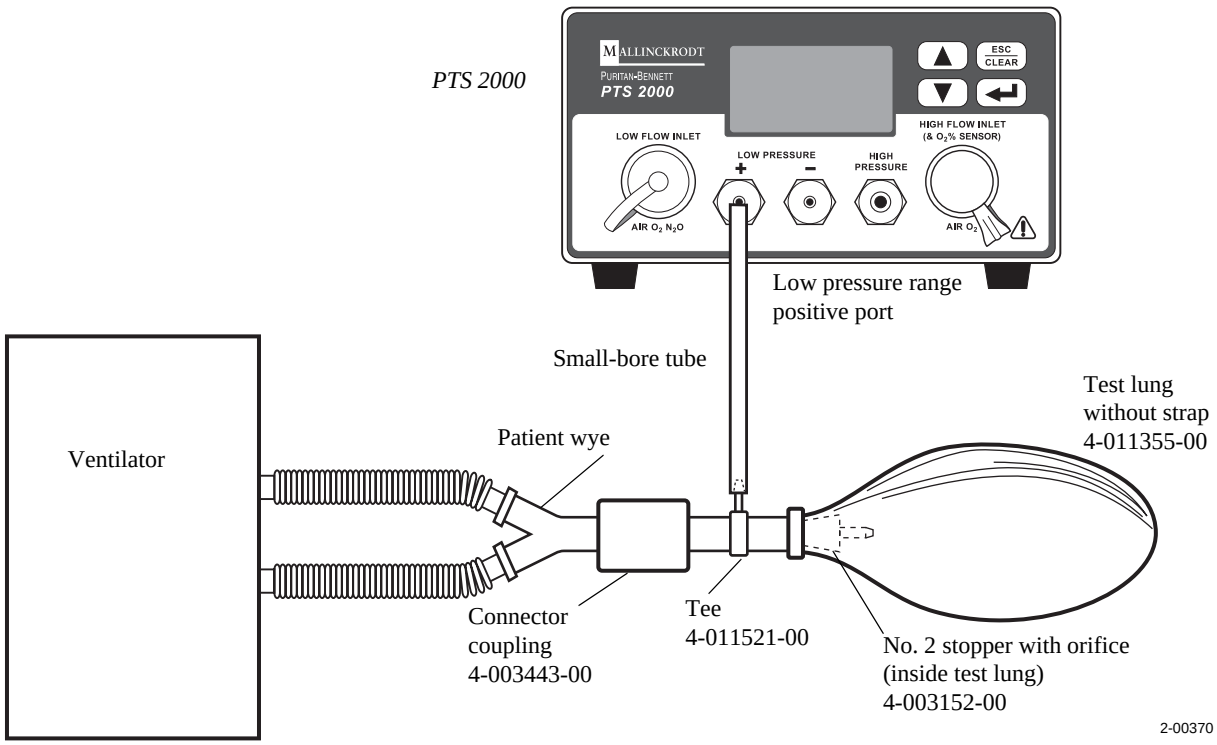


Figure 7-9. Setup for Test 14, Step 3

4. Set digital <PEEP/CPAP> to 10 cmH_2O.
5. Press <MANUAL INSPIRATION>.
6. **VERIFY** that ventilator analog meter or bar graph display reads between 8 and 12 cmH_2O. (See Section 7.8, *Item 28* for troubleshooting information.)
7. **VERIFY** that test instrument reads between 8 and 12 cmH_2O. (See Section 7.8, *Item 29* for troubleshooting information.)
8. Set digital <PEEP/CPAP> to 30 cmH_2O.
9. **VERIFY** that ventilator analog meter or bar graph display reads between 27 and 33 cmH_2O. (See Section 7.8, *Item 28* for troubleshooting information.)
10. **VERIFY** that test instrument reads between 27 and 33 cmH_2O. (See Section 7.8, *Item 29* for troubleshooting information.)
11. Turn <PEEP/CPAP> knob to maximum.
12. **VERIFY** that ventilator analog meter or bar graph display reads above 45 cmH_2O. (See Section 7.8, *Item 28* for troubleshooting information.)

13. **VERIFY** that test instrument reads above 45 cmH_2O. (See Section 7.8, *Item 29* for troubleshooting information.)
14. Set <PEEP/CPAP> to 20 cmH_2O.
15. Remove coupling and tee from patient circuit.
16. Turn ventilator power off.
17. Restore patient tubing circuit to normal configuration.

7.6.15 Oxygen Percentage Accuracy Test (Test 15)

This test verifies the accuracy of the percentage of oxygen delivered to the patient. The test instrument must be calibrated to measure oxygen percentage accurately.

1. Set up the ventilator as follows (**bold** indicates settings change from end of Test 14):

Oxygen Percentage Accuracy Test (Test 15) Settings

Control	Setting
Analog meter (basic console only)	<AIRWAY PRESSURE cmH_2O>
<PEEP/CPAP> knob	Off
cmH_2O digital display	**<PEAK AIRWAY PRESSURE>**
RATE/I:E digital display	<RATE bpm>
liters digital display	<TIDAL VOLUME>
<NEBULIZER>	Off
Mode	<CMV>
Waveform	Square
<TIDAL VOLUME>	**0.25 liter**
<RESPIRATORY RATE>	**10 bpm**
<PEAK INSPIRATORY FLOW>	20 lpm
<SENSITIVITY>	20 cmH_2O
<O_2%>	**30%**
<PLATEAU>	0 seconds
<HIGH PRESSURE LIMIT>	120 cmH_2O (except German ventilators) 100 cmH_2O (German ventilators only)
<LOW INSPIRATION PRESSURE>	3 cmH_2O
<LOW PEEP/CPAP PRESSURE>	0 cmH_2O
<LOW EXHALED TIDAL VOL>	0 liters
<LOW EXHALED MINUTE VOL>	0 liters
<HIGH RESPIRATORY RATE>	0 bpm
Apnea interval	60 seconds
Automatic sigh	Off
Power	On
Patient wye	test lung
Humidifier (if applicable)	Off

2. ***PTS 2000* and *BreathLab*:** Select the *% Oxygen (0-100%)* parameter or *All Parameters* screen for display.

NOTE:
After changing the <O_2%> setting on the ventilator, wait until the oxygen monitor reading stabilizes before taking a reading.

3. Connect the test instrument as shown in Figure 7-2, with a test lung connected to the patient wye.

4. **VERIFY** test instrument reads between 27 and 33%. (See Section 7.8, ***Item 27*** for troubleshooting information.)
5. Select these ventilator settings:

Waveform	**Descending ramp**
<TIDAL VOLUME>	**1.5 liters**
<PEAK INSPIRATORY FLOW>	**100 lpm**

6. **VERIFY** test instrument reads between 27 and 33%. (See Section 7.8, ***Item 27*** for troubleshooting information.)
7. Select these ventilator settings:

<TIDAL VOLUME>	**0.25 liters**
<PEAK INSPIRATORY FLOW>	**60 lpm**
<O_2%>	60%

8. **VERIFY** test instrument reads between 57 and 63%. (See Section 7.8, ***Item 27*** for troubleshooting information.)
9. Select these ventilator settings:

Waveform	**Square**
<TIDAL VOLUME>	**1.5 liters**
<RESPIRATORY RATE>	5 bpm
<PEAK INSPIRATORY FLOW>	**20 lpm**

10. **VERIFY** test instrument reads between 57 and 63%. (See Section 7.8, *Item 27* for troubleshooting information.)
11. Select these ventilator settings:

<PEAK INSPIRATORY FLOW>	**60 lpm**
<O_2%>	80%

12. **VERIFY** test instrument reads between 76 and 84%. (See Section 7.8, *Item 27* for troubleshooting information.)
13. Select these ventilator settings:

Waveform	**Sine**
<TIDAL VOLUME>	**0.25 liters**
<PEAK INSPIRATORY FLOW>	**100 lpm**

14. **VERIFY** test instrument reads between 76 and 84%. (See Section 7.8, *Item 27* for troubleshooting information.)
15. Remove the test instrument from the patient circuit.

7.6.16 Heated Exhalation Bacteria Filter and Power Disconnect Alarm Test (Test 16)

This test verifies the performance of the exhalation bacteria filter heater and the power disconnect alarm.

1. Set up the ventilator as follows (**bold** indicates settings change from end of Test 14):

Oxygen Percentage Accuracy Test (Test 15) Settings

Control	Setting
Analog meter (basic console only)	<AIRWAY PRESSURE cmH_2O>
<PEEP/CPAP> knob	Off
cmH_2O digital display	**<PEEP/CPAP>**
RATE/I:E digital display	<RATE bpm>
liters digital display	<TIDAL VOLUME>
<NEBULIZER>	Off
Mode	<CMV>
Waveform	**Square**
<TIDAL VOLUME>	0.25 liter
<RESPIRATORY RATE>	5 bpm
<PEAK INSPIRATORY FLOW>	100 lpm
<SENSITIVITY>	20 cmH_2O
<O_2%>	80%
<PLATEAU>	0 seconds
<HIGH PRESSURE LIMIT>	120 cmH_2O (except German ventilators) 100 cmH_2O (German ventilators only)
<LOW INSPIRATION PRESSURE>	3 cmH_2O
<LOW PEEP/CPAP PRESSURE>	0 cmH_2O
<LOW EXHALED TIDAL VOL>	0 liters
<LOW EXHALED MINUTE VOL>	0 liters
<HIGH RESPIRATORY RATE>	0 bpm
Apnea interval	60 seconds
Automatic sigh	Off
Power	On
Patient wye	test lung
Humidifier (if applicable)	Off

NOTE:
If power to the ventilator has been turned off for an extended period of time, allow 10 minutes for the exhalation bacteria filter heater to warm up before checking heater temperature.

2. **VERIFY** that exhalation bacteria filter heater is warm to the touch. (See Section 7.8, *Item 31* for troubleshooting information.)
3. Unplug ventilator, leaving power switch on.
4. **VERIFY** that audio alarm sounds. (See Section 7.8, *Item 32* for troubleshooting information.)

5. Turn off ventilator power.
6. Plug ventilator back in.
7. Turn ventilator back on.

7.7 Returning Ventilator to Operation

Restore the ventilator to a fully operational state as follows:

1. Disconnect and remove all test equipment, tools, and materials from ventilator.
2. Rerun electrical safety test if any repairs were made.
3. Reinstall top and back ventilator panels and compressor panels.
4. After reassembling ventilator, run Total EST.
5. Notify appropriate hospital personnel that normal ventilator operating parameters must be restored before ventilator can be used on a patient.
6. A Total EST must completed to restore calibration data for test 57, 58, etc. If override is selected, the data will be lost.

7.8 Troubleshooting

Use this troubleshooting information in conjunction with the performance verification tests.

NOTE:
This troubleshooting information assumes EST has passed. Use Section 6 to diagnose EST failures. Some specifications for the performance verification are tighter than for EST.

1. **Ground line resistance >0.1 Ω**
   a. Check for short circuits across or visible damage to power cord. Verify secure connections of ground wires and wires at terminal block in utility panel.
   b. Try another ac outlet.
2. **Leakage current out of specification**
   a. If compressor is connected, disconnect it and remeasure.
   b. If humidifier is connected, disconnect it and remeasure.
   c. Check for damage to power cord.
   d. Replace compressor shock mounts.
   e. Replace compressor.
   f. Replace power supply.
   g. Replace surge suppressor.
3. **Current draw out of specification**
   a. Turn off humidifier, and disconnect it from electrical source. Recheck current draw. If current draw is now within specification, service humidifier.
   b. If ventilator has a compressor, connect ventilator to wall air to turn compressor off. Recheck current draw. If current draw is now within specification, service compressor.
   c. Service power supply.
4. **Compressor and ventilator cooling fans not operating properly**
   a. Verify ac voltage to fan.

b. Replace fan.

5. POST and Total EST not passed

a. Refer to error code section (Section 6).

6. REG4 cracking pressure and full back pressure too low

a. Adjust REG4.

7. POST error codes following power interruption

a. Check battery voltage. If low, check battery charger voltage.

b. Check for defective diode CR1 on motherboard. If diode is defective, replace motherboard.

c. If 1401 or 1501 error code persists, troubleshoot per Section 6.

8. Ventilator settings changed due to power interruption

a. Check battery voltage. If low, verify that batteries are securely connected and that battery charger voltage is within range (Section 14.5).

b. Replace 80188 CPU PCB or memory PCB.

c. Replace motherboard.

9. Lamps, indicators, displays, audio alarm, or analog meter not active during lamp test

a. If audio alarm is not active, check diode CR2 on motherboard. Replace motherboard if CR2 is defective.

b. Replace audio alarm harness or analog meter harness, as appropriate.

c. Replace front panel display PCB.

d. Replace DCI-display controller or display controller PCB or display cable.

e. Replace conversion PCB, interface PCB, or interconnecting cables.

f. Replace analog meter.

10. Voltage levels out of specification at analog output connector

a. Check for open or short circuits in utility panel harness (P/N 4-019239-00) between analog output connector and motherboard.

b. Reseat interface and conversion PCBs. Check condition of motherboard connectors.

c. Replace interface PCB.

d. Replace conversion PCB.

11. Power supply voltages out of specification

a. Adjust power supply output voltages per Section 11.

b. Replace power supply or appropriate power supply module.

12. Keyboard test failed

a. Verify proper operation of audio alarm.

b. Replace keyboard.

c. Replace front panel display PCB.

d. Replace DCI-display controller or display controller PCB.

13. Regulated air pressure out of range 9.9 to 11.0 psig (68.26 to 75.85 kPa)

a. Verify source pressure and flow.

b. Check filters F3, F4, and F10. Replace as necessary.

c. Check for obstruction in CV2. Replace as necessary.

d. Check for leaky compressor check valve CV4.

e. Adjust REG2.

f. Replace REG2.

14. Regulated compressor pressure out of range 9.9 to 11.0 psig (68.26 to 75.85 kPa)

a. Check for occluded compressor inlet and outlet filters (F5 and F6).

b. Check for gross leaks in pulsation damper or plastic tees.

c. Check for obstruction in CV4.

d. Adjust/replace REG3.

e. Replace compressor.

f. Check for leaky CV2. Replace CV2 if necessary.

g. Make sure SOL9 is closed after compressor startup. If it is not, replace SOL9 or adjust/replace PS3.

15. Regulated oxygen pressure out of range 9.9 to 11.0 psig (68.26 to 75.85 kPa)

a. Verify source pressure and flow.

b. Check filters F1, F2, and F11. Replace as necessary.

c. Adjust REG1.

d. Replace REG1.

16. Oxygen flow less than 162 lpm

a. If flow was close to 180 lpm during EST test 566 but less than 162 lpm during performance verification test 10, step 6, the flow reading is in error. Do the following:

b. Replace Q1/T1.

c. Replace interface PCB.

d. Replace conversion PCB.

e. If flow was low during EST test 566 and performance verification test 10, step 6, the ventilator was unable to reach the required flow. Do the following:

f. Verify source pressure under high flow conditions.

g. Check internal diameter of air supply hose.

h. Verify that filters F1, F2, and F11 are not obstructed.

i. Repeat test steps, verifying that REG1 pressure is a minimum of 8 psi.

j. Replace interface PCB.

k. Replace proportional solenoid valve group.

17. Air flow less than 162 lpm

a. If flow was close to 180 lpm during EST test 566 but less than 162 lpm during performance verification test 10, step 11, the flow reading is in error. Do the following:

b. Replace Q2/T2.

c. Replace interface PCB.

d. Replace conversion PCB.

e. If flow was low during EST test 566 and performance verification test 10, step 11, the ventilator was unable to reach the required flow. Do the following:

f. Verify source pressure under high flow conditions.

g. Check internal diameter of air supply hose.

h. Check filters F3, F4, and F10. Replace as necessary.

i. Repeat test steps, verifying that REG2 pressure is a minimum of 8 psi.

j. Replace interface PCB.

k. Replace proportional solenoid valve group.

18. Compressor air flow less than 110 lpm with maximum PEEP

a. Verify that there is no obstruction in tubing to compressor or in compressor inlet or outlet filter (F5 or F6).

b. Verify that there is no flow coming out of air inlet port.

c. Adjust REG3.

d. Replace compressor.

19. Compressor pressure less than 7.4 psig at high flow

a. Verify that there is no flow coming out of air inlet port.

b. Check for leaks in pulsation damper and plastic tees.

c. Verify that there is no obstruction in tubing to compressor or filters.

d. Check SOL9 for leaks.

e. Replace REG3.

f. Replace compressor.

20. Resistance across nurse's call relay out of range

a. Check for a short circuit in utility panel harness (P/N 4-019239-00) between analog output connector and motherboard.

b. Replace interface PCB.

21. Analog meter or patient pressure display does not read proper value or high pressure limit alarm does not activate when patient wye blocked

a. Check for tubing leak.

b. Verify that analog meter (if applicable) reads -20 cmH_2O when power is off. Readjust meter, if it does not.

c. Replace pressure transducer PCB.

d. Replace analog meter.

22. Too much resistance across nurse's call relay during alarm condition

a. Verify wiring of 9-pin test connector, checking for high resistance or short circuits.

b. Replace interface PCB.

23. Audio alarm does not operate properly

a. Replace utility panel harness fuse.

b. Replace audio alarm.

c. Replace power switch.

d. Check for blown diode CR2 on motherboard. Replace motherboard if necessary.

e. Replace interface PCB.

f. Replace DCI-display controller or display controller PCB.

g. Replace front panel display PCB.

h. Replace utility panel harness, which includes alarm potentiometer.

24. Resistance across nurse's call relay not infinite when alarm is off

a. Check for a short circuit in wiring to NURSE'S CALL circuitry.

b. Replace interface PCB.

25. Delivered gas volumes out of range

a. Verify that RT-200 is in BTPS mode and is zeroed.

b. Check for tubing leak or obstruction.

c. Replace oxygen or air flow sensors, Q1/T1 or Q2/T2, depending upon step failed.

d. Replace interface PCB.

e. Replace conversion PCB.

26. Sensitivity problems

a. Verify that analog meter (if applicable) reads -20 cmH_2O when power is off and 0 cmH_2O during exhalation (at PEEP of 0 cmH_2O). If measurements are off, readjust meter. If analog meter still reads greater than 0 cmH_2O during exhalation (at PEEP of 0 cmH_2O), check for pressure trapped in patient circuit.

b. Check for improperly functioning check valve CV5. Replace CV5 if necessary.

c. Check patient pressure connections in exhalation compartment and pneumatic chassis.

d. Replace analog meter (if applicable).

e. Replace pressure transducer PCB.

f. Replace exhalation valve.

27. Oxygen percentages out of range

a. Make sure oxygen analyzer is properly calibrated.

b. Replace gel and membrane cap on oxygen analyzer.

c. Replace oxygen sensor.

d. Try another oxygen analyzer.

e. Replace proportional solenoid valves.

f. Replace conversion PCB.

g. Replace interface PCB.

28. Analog meter or bar graph display PEEP reading out of range

a. Check for tubing leak or obstruction.

b. Check exhalation valve area ratio linearity in EST. If ratio is nonlinear, replace exhalation valve.

c. Replace conversion PCB.

d. Install new exhalation valve.

e. Replace pressure transducer PCB.

f. Replace interface PCB.

29. Test instrument PEEP reading out of range

a. Check for tubing leak or obstruction.

b. Zero the test instrument.

c. Try another pressure gauge.

30. Test instrument PEEP reading out of range

a. Replace SOL7.

b. Clean interface or conversion PCB contacts.

c. Check for poor connection between pneumatic harness and motherboard. If necessary, replace harness.

31. Exhalation bacteria filter not warm

a. Verify power to heater using DMM.

b. Replace heater assembly.

32. Power disconnect alarm test failed

a. Verify battery voltages.

b. Verify battery charging circuit voltage.

c. Check for blown CR2 diode on motherboard. Replace motherboard if necessary.

d. Check power switch. Replace as necessary.

e. Check audio alarm harness (part of alarm assembly) for open or short circuits.

f. Check display cable assembly (P/N 4-019234-00) for open or short circuits.

g. Check conversion PCB interconnection cable assembly (P/N 4-019231-00) for open or short circuits.

h. Verify continuity of ventilator power switch (zero resistance when up, infinite resistance when down). Replace switch if necessary.

i. Replace audio alarm assembly.

j. Replace DCI-display controller or display controller PCB, front panel display PCB, and interface PCB, as necessary.

k. Replace conversion PCB.

33. Back-up ventilation (BUV) rates

a. Calibrate BUV tidal volumes.

b. Replace the Interface PCB.

34. Test instrument pressure reading does not match the digital pressure reading

a. Check for a tubing leak.

b. Zero the instrument.

c. Replace the Pressure Transducer PCB.